DESIGN CONSIDERATIONS FOR THE WASTE HOIST OF THE WASTE ISOLATION PILOT PLANT (WIPP)

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ABSTRACT

The U.S. Department of Energy is currently constructing the Waste Isolation Pilot Plant near Carlsbad, New Mexico. The full-scale pilot plant will demonstrate the feasibility of the safe disposal of defense-related nuclear waste in a bedded salt formation at a depth of 2160 feet below the surface. WIPP will provide for the permanent storage of 25,000 cu ft of remote-handled (RH) transuranic waste and 6,000,000 cu ft of contact-handled (CH) transuranic waste. The technical and operational principles of permanent isolation of defense waste in the geologic medium will also be demonstrated.

The waste containers are received in the waste handling building where inspections and mechanical processes are conducted. Then they are taken to the waste hoist tower above the waste shaft and loaded into a waste conveyance which is lowered down to the underground facility level by the waste hoist. The waste hoist and conveyance also transport underground personnel and equipment during routine operations.

This paper covers the major mechnaical/structural design considerations for the waste hoist and its hoist tower structure. The design of the hoist system components is described which includes the direct-drive friction hoist, conveyance, counterweight, ropes and guides, and the conveyance chairing device. Arrestors, crash beams and catch-gears are also discussed. The design of the hoist system and safety features incorporates state-of-the-art technology developed in the hoist and mining industry to ensure safe operation for transporting nuclear waste underground.

INTRODUCTION

In parallel with the program dealing with disposal of waste from nuclear power projects, the U.S. Department of Energy (DOE) is constructing the Waste Isolation Pilot Plant (WIPP) to demonstrate the feasibility of the safe disposal of defense-related nuclear waste in the bedded salt deposits of the Delaware Basin near Carlsbad, N.M. This full-scale pilot plant facility will provide for the permanent storage of 25,000 cu ft of remote-handled (RH) transuranic (TRU) waste and 6,000,000 cu ft of contact-handled (CH) TRU waste in deep underground salt beds. The WIPP facility will also demonstrate the technical and operational principles of permanent isolation of the defense waste in an underground salt formation. As a secondary objective, it will provide an experimental facility for the further understanding of the behavior of high-level waste in this geologic medium. This information will be useful for the future development of permanent repositories for defense and commercial nuclear waste.

The underground facility of WIPP is 2,160 ft below ground and near the middle of a salt formation 2,000 ft thick. The completed facility will contain a network of access drifts and storage rooms. The underground facility is connected to the surface facilities by three vertical shafts: the waste shaft, the construction and salt-handling shaft, and the exhaust shaft.

The CH waste drums and RH waste canisters are received in separate parts of the waste handling building where inspections and mechanical processes are conducted. Then the waste containers are taken to the waste hoist tower above the waste shaft and loaded into a waste conveyance which is lowered down to the underground facility level by the waste hoist. The waste hoist and conveyance also transport underground personnel and equipment during routine operations. Thus, the waste hoist performs an important operating function of the facility.

This paper covers the major mechanical/structural design considerations for the waste hoist and its headframe structure. The design incorporates state-of-the-art technology in the hoist and mining industry to ensure safe operation for transporting nuclear waste underground. At present, the hoist and headframe are under construction with completion of the work anticipated in 1986.

GENERAL DESCRIPTION OF THE HOIST AND WASTE HOIST TOWER

The waste hoist will lower or lift the waste carrying conveyance to or from the underground storage level, 2,160 ft below the surface. A tower-mounted friction hoist was designed. The direct drive hoist is mounted on a steel headframe (waste tower) over the waste shaft. The hoist headwheel is 12 ft in diameter and equipped with disc brakes. Six hoisting ropes are 1-3/8 in. in diameter, each end fastened to the conveyance and counterweight. The three tailropes are 2-¼ in. in diameter. Rope guides are provided for a smooth vertical ride. At the shaft collar and underground station, spear guides are installed for accurate landing of the conveyance. The waste tower (headframe) is fabricated of structural steel and enclosed with insulated metal siding and roof decking. Deflection sheaves for the hoisting ropes are provided to minimize the diameter of the waste shaft. The waste tower and the shaft sump are furnished with wood arrestors, catch-gears, crash beams, and other safety installations. The general arrangement of the waste hoist, waste tower, and waste shaft is shown in Figs. 1 and 2. Founded on reinforced concrete collar structure, the waste tower supports the hoist equipment and also functions as a transfer station for the waste and personnel.

The conveyance and counterweight are located and dimensioned to ensure free passage during the hoist cycle in the 19 ft inner diameter waste shaft, as shown in Fig. 3. The clearance between the conveyance and the shaft wall or shaft installations is 9 in. except in the region of the fixed guides. The clearance between the conveyance and the counterweight is at least 20 in.

OPERATING DESIGN PARAMETERS

Operational design parameters for the waste hoist system are as follows:

Operating speed of conveyance	500 ft/min
Acceleration rate	1.0 ft/sec/sec
Creep speed	.67 ft/sec
Guide entry speed	4.0 ft/sec
Deceleration rate	1.0 ft/sec/sec
Rest time (minimum)	5.5 min
Conveyance weight (w/rope fittings)	33 tons
Counterweight (w/rope fittings)	52 tons
Weight of headropes	32 tons
Weight of tailropes	32 tons
Maximum design payload (RH Waste)	45 tons
Maximum payloads/8 shift normal operation	7 trips 23 tons (lowered) 2 trips 45 tons (lowered) 2 trips (manload) 5 tons 1 round trip empty conveyance

HOIST COMPONENTS

The major components of the WIPP waste hoist system are as follows:

- o Direct-Drive Friction Hoist
- o Conveyance
- o Counterweight
- o Hoisting Ropes and Guide Ropes
- o Conveyance/Counterweight Guides
- o Conveyance Chairing Device

Direct Drive Friction Hoist

The waste hoist is a 6 rope friction-type Koepe hoist. It is mounted on the waste tower over the waste shaft, and is directly driven by a 600 hp DC motor. The armature of

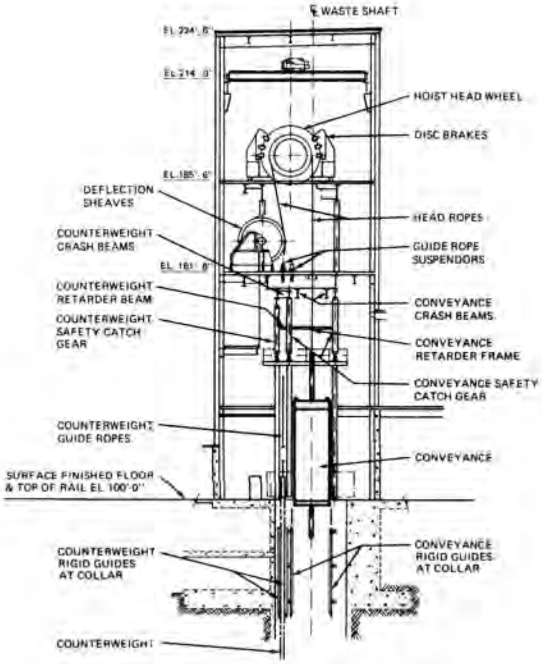

Fig. 1. General Arrangement of Waste Hoist and Headframe.

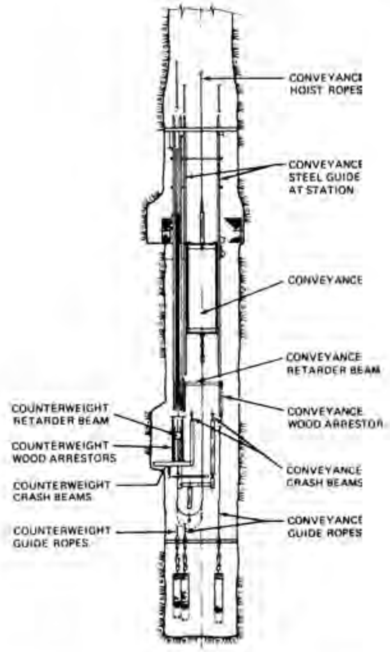

Fig. 2. General Arrangement of Waste Shaft Sump.

the motor is directly mounted on the extension of the hoist wheel shaft. In order to ensure that the hoist support possesses adequate rigidity, and to reduce interface between the design of the headframe structure and design of the hoist, a hoist bedplate is specified to be supplied by the hoist manufacturer. The bedplate is supported on the steel floor framing by three steel bearings. The steel floor framing for the hoist machinery room is designed to provide a stiff support structure for the hoisting equipment.

Conveyance

The waste hoist conveyance has two levels. The platform level of the conveyance is used only for material transport. Approximately 15 feet above the platform level, a removable deck with wire mesh on four sides is provided. This deck has a mandoor and will be used for personnel transport.

The conveyance is a steel structure of subassemblies that are field bolted together, as shown in Fig. 4. The design of the conveyance meets the following requirements:

(1) Load Combinations: The conveyance is designed for the vertical load combination of deadload, maximum payload, and forces transmitted from the hoisting ropes and tailropes during normal operations. The allowable stresses for all the steel members and connections are limited to 25% of AISC allowable stresses[1] to allow for accelerations, decelerations, impact loading, and fatigue.

(2) Operational Condition: The conveyance is designed for horizontal loads resulting from loading and unloading the payload, and the interaction between the conveyance and rigid guides during normal operation. The magnitude of the maximum horizontal loads imposed on the conveyance is estimated to be equivalent to 0.25 g from the fixed guides in the station areas during travel and 10% of the payload during loading and unloading.

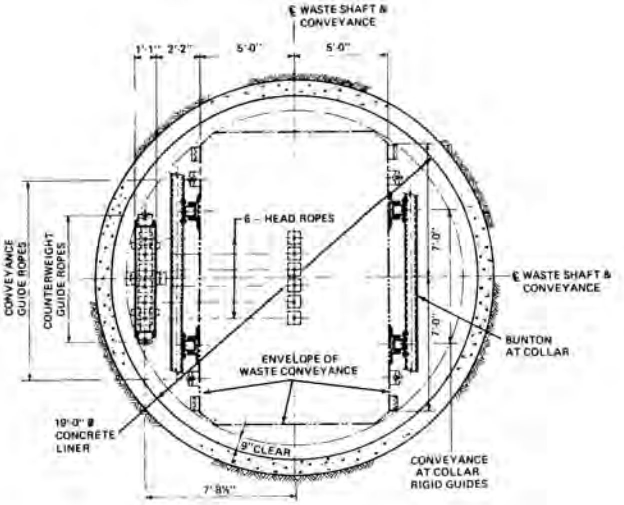

Fig. 3. Waste Shaft Cross-Section.

(3) Emergency Condition: In the event of emergency stops or the conveyance engaging the arrestors, all members and connections may be stressed up to full AISC allowable stresses.

(4) Accident Condition: In the unlikely event of an overtravelling conveyance crashing into the crash beams, which might result in breaking of the headropes, local yielding or buckling in the conveyance is acceptable. However, the four safety catch lugs and their support members on the conveyance must remain undistorted and operable after an ascending crash. These lugs and supports must be capable of holding a conveyance drop equivalent to 2.0 g, distributed to two lugs and two support members only.

Counterweight

The counterweight consists of steel frames. The weight compartments of the frames accepts removable steel or cast iron weights. The weight of the counterweight is approximately equal to the weight of the empty conveyance plus one-half the weight of the maximum payload. The weight of the

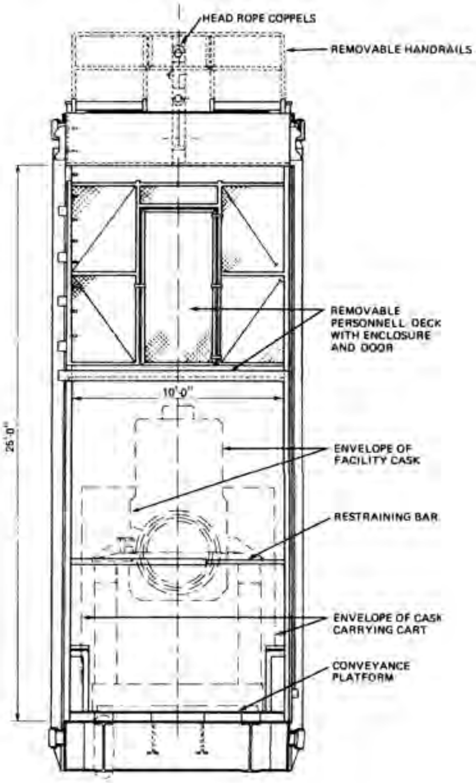

Fig. 4. Waste Conveyance.

conveyance rope fittings and of the counterweight rope fittings is included in these weight summaries.

Hoisting Ropes and Guide Ropes

Full locked coil hoist headropes are used. Guide ropes are of half-lock coil construction. Tail ropes are a nonrotating type with a synthetic fiber core. All ropes are galvanized and fabricated with internal lubrication for corrosion protection. For fire protection only minimal manual lubrication or dressing may be applied after installation.

For the conveyance with the maximum design payload, the factor of safety of the hoisting ropes is at least 5.9 as determined by ANSI M11.1[2] according to the depth of the waste shaft, and both the hoisting ropes and tailropes have a minimum endurance limit of 400,000 loading cycles. Each guide rope has tensioning cheeseweights of at least 18,000 pounds. To reduce the tendency of the guide ropes to vibrate in unison, the amount of the tensioning load on each of the guide ropes differs by about 10%. The guide ropes have a minimum factor of safety of 5.0. The effect of the Coriolis force on the waste hoist system and specifically the lateral deflection of the guide ropes, as determined by the following formula, is considered to be negligible due to the relatively slow speed:

$$F_c = 2 \frac{W_t}{g} V w \cos e \qquad (1)$$

where F_c = Coriolis force (lb)
W_t = total weight of conveyance and payload (156,000 lb)
V = operating speed of conveyance (8.33 ft/sec)
w = angular velocity of earth (7.37 x 10 r/sec)$^{-5}$
e = latitude of the WIPP site (33°)

The stretch and associated vibration of the head ropes under acceleration and deceleration conditions were analyzed so that the system was designed to keep the rope stretch within safe operating limits.

Conveyance/Counterweight Guides

The rigid guides are designed for a horizontal force from the conveyance or counterweight equivalent to 0.25 g. The total horizontal force from the conveyance or counterweight is distributed equally by top and bottom guide shoes only. In both the north-south and east-west directions, only two fixed guide rails are assumed to be engaged at one time.

Conveyance Chairing Device

A chairing mechanism is provided at the underground storage level station to support the conveyance during the unloading and loading of the waste or material and thus to prevent the sudden movement of the conveyance due to changes in the conveyance payload. The chairing mechanism consists of two movable structural members with pneumatic buffers. The chairing mechanism is operated by hydraulic cylinders. When a loaded conveyance is lowered and approaches the underground station at a reduced speed of 40 ft/min. it will be stopped 5 ft above the station by applying the brakes activated by a magnetic proximity switch. The chairs will be automatically moved into the chairing position under the conveyance. After the chairs are fully deployed, the conveyance will be automatically lowered at the same creep speed until it contacts the buffers. The buffers absorb the shock and slow the conveyance until the conveyance comes to rest on the chair. The hoist will continue to operate in a downward direction to raise the counterweight and release the headrope tension until about 150 percent of the hoist motor full-load torque is reached. By this chairing method, the headrope tension is reduced sufficiently to assure that the conveyance does not bounce upward when the heavy waste cask or other loads are removed from the conveyance. At this point, the current limiter will stop the hoist motor and apply hoist brakes. When this occurs, indicating lights at the storage level control station and master control station shall signal the completion of chairing and unloading may proceed.

Upon initiation of an up-travel signal, the brakes will be released, and the hoist will turn slowly to lower the counterweight and restore tension in the headropes on the conveyance side. Then the hoist can be safely accelerated to raise the conveyance. When the conveyance passes the chairing proximity switch, the chairs will be withdrawn automatically.

HOIST OPERATION, CONTROL AND SAFETY

Major components of WIPP waste hoist operational system are:

- Hoist Control System
- Brake System
- Wood arrestors
- Crash beams and catch-gears

The system is designed to provide the required operational flexibility and efficiency. Incorporated into the system are redundant features to ensure operational safety during hoist operation against overspeed and overtravel. Five levels of safety redundancy are provided. In order of their activation, in case of overspeed or overtravel, the features are 1) speed programmer and the proximity switches in the shaft, 2) the Lilly controller, 3) the track limit switches, 4) the wood arrestors, 5) the crash beams. In addition, *fault detection* devices are provided for all operational systems. Jamming of the conveyance or rope slip at the conveyance or rope slip at the hoist wheel is automatically detected and safety interlocks are provided for operational conditions.

Hoist Control Systems

There are four control stations for the waste hoist. The master control station is located in the hoist control room, one local control station at the waste shaft collar, and another local control station at the underground shaft station. Furthermore, control is provided in the conveyance through an FM transmitter as shown in Fig. 5. The hoist can be operated manually or semiautomatically. When transporting waste, only the semiautomatic mode will be used. In the manual mode the hoist operation is monitored and controlled by a hoist man located at the master control station. Upon transfer of command from the master control station, the local control stations and the conveyance only operate the hoist in the semiautomatic mode. The hoist operation is continuously monitored by the central monitoring system in the WIPP central monitoring room with a local processing unit located in the hoist control room.

In the semiautomatic mode the hoist operation is monitored and controlled by a digital speed programmer connected to a hoist-driven pulse generator. It is equipped with a transmitter for depth indication and overspeed protection. It is also provided in each slowdown zone to monitor the conveyance speed and position. The speed programmer facilitates control of two different operating levels of the conveyance for transportation of materials and personnel. Figure 6 shows the speed-distance profile and control points for the semiautomatic operation.

A hoist-driven Lilly Controller (Model C) is provided to initiate an emergency stop if the conveyance should travel at 15% over the design speed at any point in the hoisting cycle, or when the conveyance is beyond the limits of normal travel.

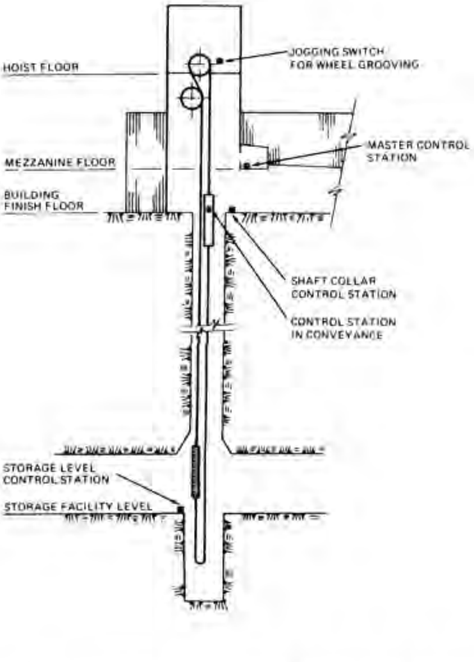

Fig. 5. Location of Hoist Control Stations.

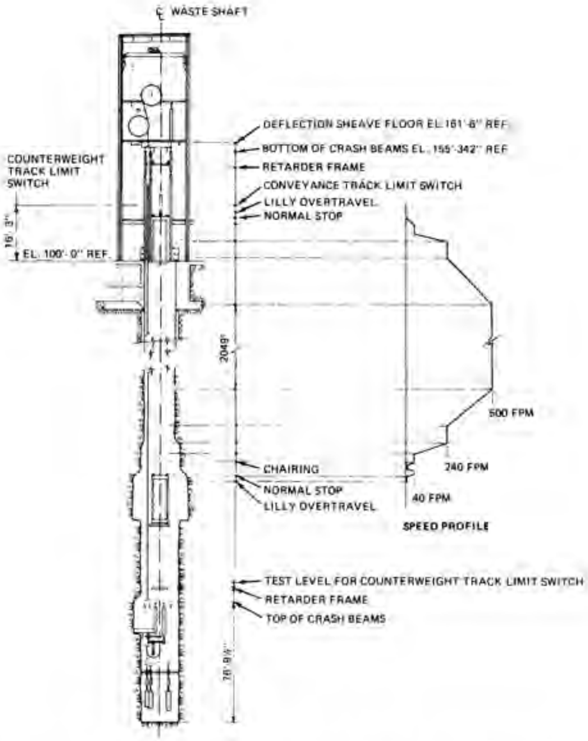

Fig. 6. Speed-Distance Profile for Semi-Automatic Operation.

Mechanical track limit switches are provided beyond the normal travelling zones which will actuate emergency stop functions on the hoist drive.

Brake System

The brakes on the hoist are sized to be capable of stopping the conveyance at a specified deceleration during operation. When the brakes are applied to the friction hoist system (Fig. 7) the equation of equilibrium can be written as follows:

$$\frac{Id_o}{r^2g} \pm W + W\frac{d_o}{g} \pm W_c + W_c\frac{d_o}{g} \mp (C+M) + (C+M)\frac{d_o}{g} - W + W\frac{d_o}{g} - B = 0 \qquad (2)$$

$$\text{or } B = (\frac{I}{r^2} + 2W + W_C + C + M)\frac{d_o}{g} \pm (W \;- C - M)$$

where B = effective braking force
I = mass moment of inertia of hoist head wheel
r = radius of hoist head wheel
W = weight of the suspended ropes on one side
C = weight of conveyance
M = weight of material or men in conveyance
W_c = weight of counter weight
g = gravitational constant, 32.2 ft/sec^2
d_o = specified deceleration.

The upper sign represents the case of the ascending conveyance and the lower sign represents the case of the descending conveyance.

The brakes are caliper type multiple disc brakes. They are operated by hydraulic cylinders and are designed to automatically apply in the event of a loss of electrical power or working fluid pressure. Furthermore, a partial failure of the brake system during an emergency is usually assumed in the design. For the WIPP waste hoist, three basic design requirements for the brakes are described as follows:

(1) In the event of a 50 percent loss of total braking effort, the remaining brake units shall be capable of retarding the conveyance at not less than 3 ft/sec^2, within the normal deceleration zone, when the maximum design payload is lowered to the maximum hoisting depth.

(2) When the conveyance carries a maximum design payload traveling at 500 ft/min, 50 percent of the total braking system shall be capable of safely stopping the conveyance within a 30-ft travel distance.

(3) During an emergency stop, with all brakes applied, deceleration of the conveyance shall not exceed 16 ft/sec^2 when personnel are carried.

These requirements determine the total braking effort (B_t) of the brake system.

Since the discs are normally built to the flanges of the hoist head wheel, the disc brake shoes and the support frames are supported by the hoist bedplate and the steel floor in the waste tower. These structural steel members are designed to accommodate the sudden exertion of forces from the brake system.

Arrestors

Overtravel arrestors are installed in the hoist tower to stop the ascending conveyance (and counterweight) in the event of an overtravel. Similarly, undertravel arrestors are installed in the shaft sump, to stop undertravel of the conveyance and counterweight. The arrestors are made of long dressed wood timbers and placed vertically. There are retarder beams resting in notches at the end of the wood arrestors. They contain deceleration knives that are forced into the arrestors when an overtraveling conveyance or counterweight strikes the retarder beams. Typical details of the wood arrestors and retarder beams are illustrated in Fig. 8.

The maximum deceleration of the ascending conveyance due to the overtravel arrestors and the brakes (if not failed) should not be greater than the gravitational acceleration g. Otherwise, the content of the conveyance will lift off the floor of the conveyance which is particularly unacceptable for the waste cask. The tail ropes will pile up under the conveyance and may then fall back with enough force to break the headropes. For the design purpose, the maximum deceleration to be imparted by the arrestors for the ascending conveyance is set at d = 30 ft/sec^2.

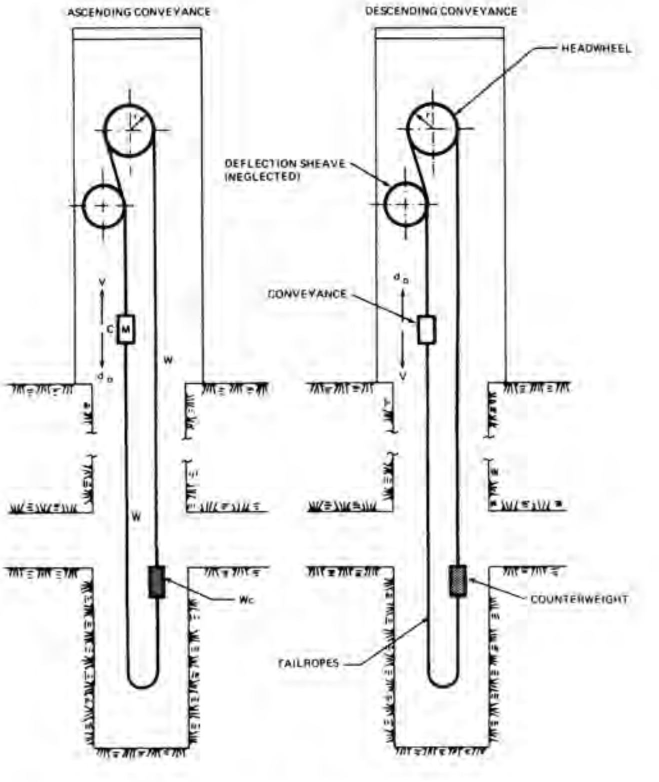

Fig. 7. Braking Effort.

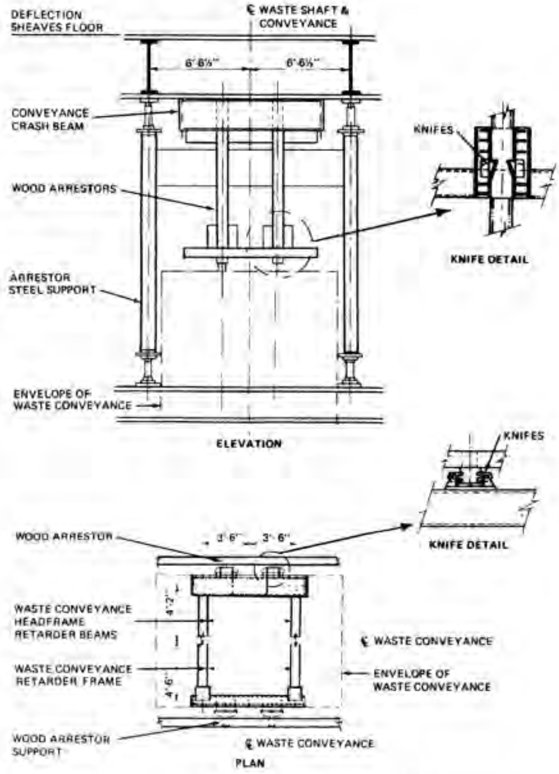

Fig. 8. Typical Details of Wood Arrestors.

The maximum safe operating speed for handling the waste is specified as V_0 = 500 ft/min, according to the rate of production. The maximum entry speed, V_e into the overtravel arrestors, could be about 15% higher. This is due to the fact that when properly adjusted, the Lilly controller should limit the hoist operating speed to 115%.

Therefore,

$$V_e = 115\% \; V_o \qquad (3)$$

Then, the minimum length of the overtravel arrestors is

$$h = \frac{V_e^2}{2d} \qquad (4)$$

The relative position of the overtravel arrestors in the headframe and the undertravel arrestors at the bottom of the shaft are arranged so that the descending counterweight or conveyance will enter the undertravel arrestors before the ascending conveyance or counterweight enters the overtravel arrestors (see Figs. 6 and 9). This is to ensure that the headropes at the lower end will slack and the descending counterweight or conveyance will not impose additional kinetic energy through the headrope to the ascending conveyance or counterweight during such an overtraveling situation. For an overtraveling conveyance (Fig. 9), the total retarding force, R_t, due to the brakes and arrestors can be expressed as follows:

$$R_t = \frac{I}{r^2}\,\frac{d}{g} + W\left(1 + \frac{d}{g}\right) - W\left(1 - \frac{d}{g}\right) - (C + M)\left(1 - \frac{d}{g}\right)$$

$$= \left(\frac{I}{r^2} + 2\,W\right)\frac{d}{g} - (C + M)\left(1 - \frac{d}{g}\right) \qquad (5)$$

The required arrestor drag is the difference of the total retarding force and the total braking effort:

$$R_r = R_t - B_t \qquad (6)$$

The governing case in this calculation is when the ascending conveyance only carries one person. The arrestor drag and the minimum arrestor length are the basic data required for the selection of overtravel arrestors for the conveyance.

Suppose the brakes failed to apply and the overtravel arrestors are solely relied upon to stop the conveyance, then the equation of equilibrium can be written as follows:

$$R_r = \left(\frac{I}{r^2} + 2W + C + M\right)\frac{d_m}{g} - (C + M) \qquad (7)$$

Therefore, the minimum deceleration (due to arrestors alone) becomes:

$$d_{min} = \frac{R_r + C + M}{I/r^2 + 2W + C + M}\, g \text{ ft/sec}^2 \qquad (8)$$

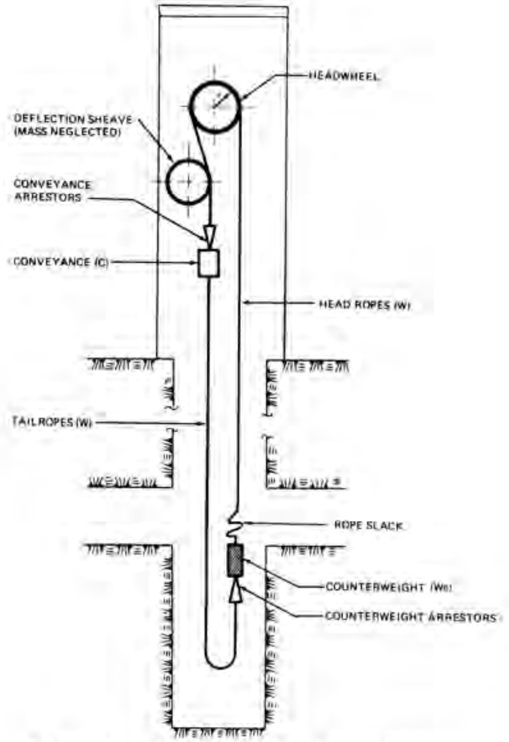

Fig. 9. Overtravel Arrestors.

The length of the conveyance overtravel arrestors, h, is checked against the safe man speed:

$$V = 2\; d_{min}\; h \times 85\% \qquad (9)$$

The safe man speed may be increased to meet operational requirements by increasing the length of the overtravel arrestors.

During an undertravel, the deceleration of a descending conveyance could be larger than the gravitational acceleration without adverse effect. When men are carried, the empty conveyance may be decelerated at approximately 3.0 g. As the conveyance enters the undertravel arrestors at the bottom of the shaft, the counterweight also approaches the counterweight overtravel arrestors up in the hoist headframe. Furthermore, the conveyance is decelerated at a deceleration greater than g, and there will be slacking in the headropes above the conveyance. At this moment, the conveyance is actually isolated from the ropes and counterweight (Fig. 10). Therefore, the undertravel arrestor drag is determined by the weight of the conveyance and the maximum permissible deceleration.

$$R_r = C \times 4 \qquad (10)$$

When the conveyance is loaded with payload, the maximum deceleration which the undertravel arrestor could provide is:

$$d_u = \frac{R_r}{C + M}\, g = \frac{4\,C}{C + M}\, g \qquad (11)$$

The undertravel arrestors should be long enough to stop a fully loaded conveyance.

$$h = \frac{V_e^2}{2d_u} \qquad (12)$$

The undertravel arrestors are supported by structural steel members which are in turn fastened to the shaft wall near the bottom. The overtravel arrestors are supported by steel members which are part of the hoist headframe. These structures are designed to be capable of resisting the arrestors' drag as calculated by the formulas shown above.

Crash Beams

The crash beam is the last line of defense against an overtraveling conveyance or counterweight crashing into the headframe or the sump structures. If the control devices such as the Lilly Controller and proximity switches as well as the brakes and overtravel arrestors should fail or partially fail, the ascending conveyance should be stopped by the crash beams before the rope attachments enter the deflection sheaves. The crash beams are located above the arrestors and below the deflection sheaves inside the hoist headframe. Normally, the crash beams are steel beams which will deform on heavy impact and absorb kinetic energy. The investigation of overtravel accidents indicates that the hoist headropes caused by the continued motion of the head ropes and hoist after the conveyance is stopped by the crash beam. Therefore, it is common practice to design the crash beams and the hoist headframe to withstand the effects of broken headropes.

If the breaking strength of the headropes is represented by P_1, the equation of equilibrium can be written as follows (Fig. 11):

$$P_1 = \frac{I}{r^2}\,\frac{d}{g} + P_2 \qquad (13)$$

$$\text{where } P_2 = W\left(1 + \frac{d}{g}\right)$$

The substitution leads to the deceleration of the conveyance during the impact:

$$d = \frac{P_1 - W}{I/r^2 + W} \qquad (14)$$

The rope breaking force P_1 applies as an internal force among the hoist floor, the crash beams, and the column struts between them. The crash beams themselves are subjected to direct impact of the conveyance. Due to the rarity of such a catastrophe, the crash beams are allowed to reach yield point and permanent deformation of the crash beams is expected. The deformed crash beams should be replaced after the overtravel accident. The force resulting from the change of momentum of the suspended headropes, P_2, is the net downward load on the hoist floor and on to the headframe columns. The steel hoist floor and columns are designed to withstand this load with an increase in the allowable stress due to the unlikelihood of such an event occurring.

The crash beams are also provided at the bottom of the shaft to stop the undertraveling counterweight or conveyance. Similar to the arrestors, the relative position of the crash beams is arranged in such a way that the descending counterweight or

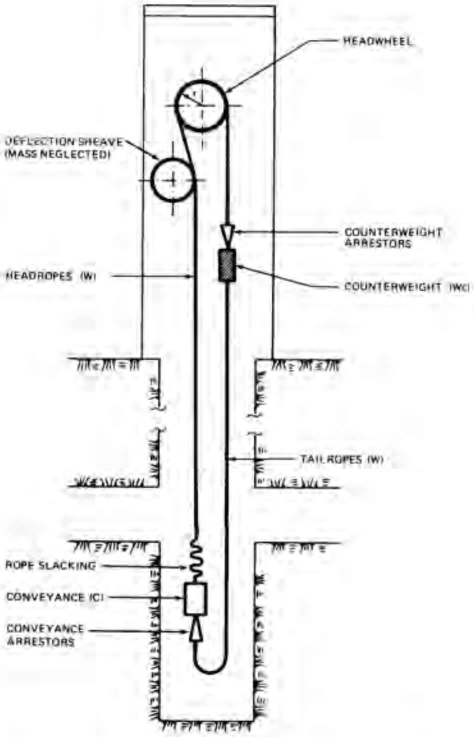

Fig. 10. Undertravel Arrestors.

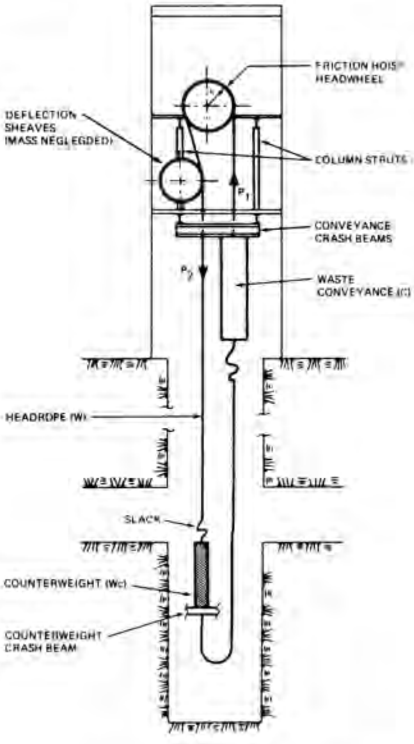

Fig. 11. Crash Beams.

conveyance will crash into the lower crash beams before the ascending conveyance or counterweight crashes into the respective crash beam in the headframe. This is to prevent an early crash or a premature rope break in the headframe.

Catch-Gears

Both the conveyance and counterweight are provided with stationary lugs that will engage the dogs of catchgear units in the waste hoist tower, if the accidental overtravel and fall-back of either should occur. This will prevent their falling down the full depth of the hoist shaft if the hoist ropes break. At its base, the catch-gear is supported by a shock absorber that fastens to the support framing. The live load transmitted to each shock absorber support member is limited to 2.0 g.

Other Safety Features

In addition to the conveyance overspeed and overtravel, jam of the conveyance at the stations or other locations will also impose a safety hazard. If a descending conveyance jams without being detected, the hoist wheel would continue to rotate, payout ropes to the top of the conveyance and lift up the tailropes. As the weight on the conveyance increases, the conveyance might unjam and suddenly drop down and thus break the headropes. In order to prevent such an accident, a trip wire is installed through the tailrope loops and linked to a magnetic switch. Should the tailrope loops be elevated because the conveyance jammed, it would trigger the wire and switch to initiate an emergency stop on the hoist. If the ascending conveyance jams without being detected, excessive pull would normally result in slippage of the headropes over the hoist headwheel. A rope-driven tachogenerator is provided near the headwheel. By comparing the voltages from the rope-driven tachogenerator and from a motor-driven tachogenerator, which is part of the speed control programmer, the rope slippage is detected and the emergency stop is initiated. In the event that the headropes are somehow caught by the headwheel during a conveyance jam, the motor torque and current would increase rapidly. A stall switch is provided for the hoist motor to limit the current to 200% of the normal load and initiate an emergency stop.

Interlocks are provided at each station level to insure that the hoist cannot be operated before the conveyance is fully loaded or unloaded.

Investigation of mine accidents indicated that most have resulted from improper operation or poor maintenance. One good example is the use of electrical jumper wires for repair. These jumpers if not removed may short-circuit the safety devices and thus enhance the possibility of an accident. Therefore, a stringent procedure for operation and maintenance is an integral part of the safety program.

CONCLUSIONS

The WIPP waste hoist is equipped with the most advanced digital control and monitoring systems available. The hoist operation is also continuously monitored by the central monitoring system. The hoist control system is provided with overspeed and overtravel protection. In addition, Lilly Controller and mechanical track limit switches are provided as redundant safety devices to prevent the conveyance from overspeeding or overtraveling. Furthermore, arrestors, crash beams, and catch-gears are installed above and below the limits of regular travel of the conveyance and arranged to prevent overtravel in the event of failure of other devices. The major components of the hoist system such as the conveyance and hoisting ropes and headframe structure are designed according to the code requirements and conservative design practice in the industry to provide ample margin of safety. It is believed that the WIPP waste hoist system satisfies the operational and safety requirements for transporting nuclear waste into the underground facility.

REFERENCES

1. American Institute of Steel Construction, Manual of Steel Construction, AISC-M011-80, 8th Edition.

2. American National Standards Institute, Wire Rope for Mines, M11.1-1980.